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PARTNERSHIPS AND THE FUTURE OF NASA

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Partnerships have become a more integral part of the journey to Mars as NASA continues to lead human space exploration. The current budgetary and political reality requires that partnerships be a key component of moving beyond Low Earth Orbit. This paper will discuss the challenge of finding innovative partnerships that take advantage of the capabilities of the growing commercial space market. Challenges include identifying specific technological needs, recognizing the growing expertise and desires of commercial space to move beyond Low Earth Orbit, incorporating commercial partners into the Mars Roadmap, and working with international partners.

INTRODUCTION

During the 1960's, NASA funding was approximately 5% of the United States (U.S.) federal budget and the agency had a clear goal of landing on the moon within the decade. This goal was promoted by the political ambitions of the administration and enthusiastically supported by American public. Fifty years later, the agency's funding is approximately 0.5% of the U.S. federal budget and the focus of politics has mostly shifted away from space flight, despite strong public interest of NASA missions, as evidenced by world wide social media followers. For example, @NASA is the 104th most popular Twitter account in the world, with over 11 million followers.[1] ….. The ability of NASA to move Human Space Flight (HSF) beyond low Earth orbit and meet its overall strategic goals of:

- Expanding the frontiers of knowledge, capability, and opportunity in space
- Advancing understanding of Earth and developing technologies to improve the quality of life on our home planet
- Serving the American public and accomplishing our Mission by effectively managing our people, technical capabilities, and infrastructure

requires a fundamental shift in strategy.

The National Space Policy of the United States[2], set in 2010, recognized that "a robust and competitive commercial space sector is vital to continued progress in space". Therefore the United States is committed to encouraging and facilitating the growth of a U.S. commercial space sector that supports U.S. needs, is globally competitive, and advances U.S. leadership in the generation of new markets and innovation-driven entrepreneurship.

The International Space Station Program is an outstanding example of international governmental partnerships and "is becoming the focal point for the first tentative steps in commercial cargo and crewed orbital spaceflights."[3] NASA has been actively encouraging the commercial space sector, as evidenced by the commercial cargo and commercial crew programs, efforts in commercialization of ISS-based research, and technology development partnerships. Yet all these efforts, as important and innovative as they are, do not yet amount to a cohesive strategy that demonstrates how NASA and its partners are going to "embark on human space exploration beyond LEO in a sustained and sustainable fashion"[3] in the new era of economic, geopolitical and technological realities.

This paper, originated in the Johnson Space Center (JSC) in Houston focuses on commercial aspects of NASA partnerships and represents a potential JSC strategy of leading a global enterprise in human space exploration that is sustainable, affordable, and benefits all humankind.

STRATEGY CONSIDERATIONS

Partnership Potential

Multiple previous studies and assessments, the most recent performed by NRC HSF Committee concluded that "a program of human space exploration beyond low Earth orbit (LEO) … is not sustainable with a budget that increases only enough to keep pace with inflation."[3] This major driver for NASA strategy shift coincides with worldwide changes in political, technological and market areas.

Space, once reserved to a very few governments, is becoming common practice and attracts more and more players, governmental and commercial. Organization for Economic Co-Operation and Development (OECD) recognizes "The space sector plays an increasingly pivotal role in the functioning of modern societies and their economic development". Their publication *The Space Economy at a Glance 2014*[4] shows that while space budgets in the 34 OECD countries totalled USD 50.8 billion in 2013, down from USD 52.3 billion in 2008, the combined space budget of the BRICs (Brazil, Russia, India and China) swelled to USD 24.0 billion from USD 16.5 billion over the same period and provides a statistical overview of the global space section and its contributions to the economic activity."

In HSF, the U.S. and Russia, the only two countries who have launched humans into space, are now joined by a third player, China. In addition, the inherently expensive and risky endeavour of HSF is beginning to attract commercial activity. Most such initiatives still focus on government markets, yet there are a few, such as SpaceX and Virgin Galactic, that do not desire to be government business-dependent.

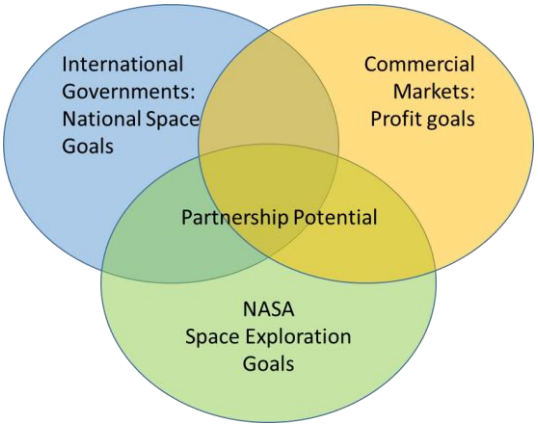

Figure 1, Alignment of Goals Leading to Partnerships

As simplistically demonstrated in Figure 1, Alignment of Goals Leading to Partnerships, there should be no expectation of full alignment of space-related goals to find common areas. These areas of alignment represent the full potential of partnerships on the road to space exploration.

Paradigm Shift

In 2006, NASA awarded the Commercial Orbital Transportation Services (COTS) to SpaceX and Orbital Sciences. The idea of using non-traditional commercial space partners was met with skepticism by some. However, the exapanding technical capability of the commercial space industry and the fluid political environment required a new paradigm. Eventually, the successful cargo resupply flights completed by SpaceX and Orbital resulted in a shift in the way in which new entrants into the field were viewed.

As the success of COTS became apparent and NASA began to look at a future without the Space Shuttle, it was natural to consider commercial providers for crewed missions to the International Space Station (ISS). In 2014, NASA selected Boeing and SpaceX to provide human rated transportation systems to ISS. Boeing is expected to launch its first flight in 2017. Other companies such as the Sierra Nevada Corporation, Virgin Galactic, XCOR, and Bigelow Aerospace are also continuing their development of human-rated space systems, which NASA may be able to leverage in the future. It is readily apparent that all of these commercial space companies are "standing on the shoulders of giants" by taking advantage of NASA's vast HSF experience and Research & Development (R&D) work.

Moreover, some commercial space companies have the vision of becoming major space exploration players and are working on their own exploration plans independent of NASA. We are at the cusp of another paradigm shift. Historically, NASA partnerships with commercial space companies have been mainly limited to smaller one-time projects, with NASA providing unique expertise and testing. However, the emerging commercial space industry is pushing the boundaries of NASA's traditional understanding of partnerships by offering opportunities for new partnership models that contribute to the independent goals of commercial space companies, yet can be extremely beneficial to NASA on the road to explore new destinations. This paradigm shift is also dispelling some of the myths that NASA and commercial space companies are in a competitive, zero-sum game. In reality, NASA and commercial space companies can work together collaboratively and synergistically so that both are able to thrive.

Integration and Business Model

Current NASA budgets are insufficient for sustainable exploration beyond LEO (utilizing traditional development models). While the international community agrees on Mars as the ultimate destination, their near-term interest is the exploration of the Moon. Current NASA policy, however, is focused more on other destinations[5]. The challenge NASA faces is how to capitalize on common goals and build a strategy that integrates international and commercial players, traditional and non-traditional relationships, and contractual mechanisms.

The question is how NASA should collaborate with commercial space companies while advancing its expertise and leading the international community beyond Low Earth Orbit (LEO). Plans for executing such an endeavour should be developed in consultation with international governmental partners and commercial space companies. In addition, the value proposition for the American taxpayer needs to be communicated to show how NASA's technology development goals overlap well with the technologies needed to benefit the economy and society.

Through its leadership with Space Station program, its experience with Commercial Cargo and Crew, and current efforts of commercial research and technology development, JSC has a rich partnership experience base. JSC is home to many leaders with international integration expertise that are capable of defining and executing commercialization strategies, extending partnership dialog to non-traditional partners. JSC 2014 strategic goals include leading human exploration and leading internationally. Expertise acquired in JSC as a leader in current and past international and commercial partnerships provides the basis for the following concepts.

ELEMENTS OF THE STRATEGY

While NASA has the obligation to support the emerging U.S. commercial space sector with the knowledge it acquired to date, it is also critical that the agency continues to push the bounds and lead technology development and integration of human space mission efforts.

One way that NASA is continuing technology development is through the use of Space Act Agreements (SAAs). NASA was authorized by the National Aeronautics and Space Act of 1958 to "enter into and perform such contracts, leases, cooperative agreements, or other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate".[6]

Through the use of a SAA, NASA can provide, on a reimbursable basis, unique expertise or unique facilities to commercial space companies. This allows commercial space companies to learn from NASA experience and/or use facilities that would otherwise be too expensive to build and maintain.

NASA can also enter into a non-reimbursable SAA, which allows for collaboration on a no funds exchanged basis. For areas of mutual interest, NASA and its partner can commit to research and development in a specific area. The exchange of ideas and commitment to advancing technological needs has the potential for increasing the technology readiness level (TRL) more quickly than if NASA and the partner worked independently.

It would be a detriment to the U.S. and to NASA not to take full advantage of commercial space companies' capabilities, and not only those existing today, but expected future capacity. By working with industry now to identify new market opportunities, NASA and its commercial partners can sow the early seeds of market adoption as NASA begins to push the envelope of beyond LEO exploration.

For example, Elon Musk, SpaceX founder, has clearly stated that he has the intention of going to Mars[7]. Another example is Bigelow Aerospace, which is working on its B330 Module, a design evolved from NASA's TrasnHab habitat concept. The B330 has potential to be used not only in LEO but also as a craft for mission for the Moon and Mars.

NASA should take advantage of the natural synergy between the agency and commercial space companies. The goal is to work together to provide the biggest benefit to humanity and push our experiences beyond LEO. This requires a long-term collaboration strategy. At a 2014 U.S. House of Representatives Committee hearing on Science, Space, and Technology, The American Institute of Aeronautics and Astronautics (AIAA) Executive Director stated,

> *"The role of government is to do the "hard" things; invest in the research and development that industry cannot, and to take on the tasks and push the boundaries that the private sector will not. Our strategy should encompass not only exploration but what we hope to accomplish in low Earth orbit and to encourage an economically viable industry there. We should consider how we want the U.S. to be leveraged for future roles in space, both in commercial and civil, in low Earth orbit and beyond. It should not be an "or," it should be an "and". "*[8]

Strategic partnership development is a key enabler of both current and future agency mission objectives. There are existing commercial companies for spacecraft and launch vehicle providers that enable the commercialization of LEO. The market for human spaceflight, microgravity, and spaceport construction is maturing. In the future, commercial entities may focus on space resources or space based energy. In a recent market assessment, the New Space Global (NSG)

organization suggested that there were eight different verticals ranging from existing mature markets to some of the more speculative, potential markets. Figure 2 illustrates these 8 market verticals. [9]

Figure 2, NSG NewSpace Verticals

In all of these areas, the opportunity to have partnerships for the development of deep space exploration capabilities is key to enabling NASA to be Mars "ready".

The essential principles for these partnerships are mutual benefits and alignment with the agency goals (figure 1). As we think about strategy, there are key questions to consider:

- What is the right framework under which NASA can best integrate the capabilities of commercial, international, and other U.S. government entities into a coherent exploration strategy?
- Although the end application may be different, which underlying technologies would advance both beyond LEO exploration as well as Commercial Space markets?
- Which capabilities does NASA want to own and further develop? Which capabilities are better suited for commercialization with NASA as a buyer?
- What commercial capabilities or new market opportunities would be disruptive to the way NASA approaches future exploration missions?
- How can NASA best take advantage of Commercial Space goals that align with the human exploration goals of the Agency?
- Which partnerships with Commercial Space companies would maximize NASA's relevancy?

A two-pronged strategic approach will help NASA maximize the value of strategic partnerships. One purpose of entering into a partnership is to close existing Mars mission technology gaps. The co-development of new technologies for Mars missions would reduce the time and NASA funding required. If the partnership can reduce total lifecycle costs, this would free up NASA resources for beyond LEO. The agency could leverage new commercial flight opportunities to perform risk reduction/tech demo. One of the challenges for the agency is to not allow the commercial motivations (for profit) and/or formats (e.g. "entertainment") to impact the analysis of technical alignment and strategic value.

The other part of the strategic approach is to maximize relevancy to help gain additional public support for future Mars missions. By partnering more with private enterprise, NASA will help accomplish this goal by further expanding its positive economic influence.

In 2014, NASA's Human Exploration and Operations Mission Directorate put out a call for partnership initiatives for:

- Collaborations on the Asteroid Initiative via the Asteroid Redirect Mission Broad Agency Announcement
- Joint development of a robotic lander via Lunar Cargo Transportation and Landing by Soft Touchdown Announcement
- Collaborations for Commercial Space capabilities (CCSC), which included exploration capabilities in all areas of NASA's interested (other than above)
- International Space Station (ISS) additional commercialization activities

The objectives of CCSC Agreements is "to advance private sector development of integrated space capabilities so that the emerging products or services are commercially available to government and non-government customers within approximately the next five years". This is just one example of how the agency is continuing to evolve into a more industry focused, economically friendly organization.

SUMMARY

NASA is facing significant external and internal challenges on its' path of leadership in Space Exploration, yet NASA is moving outside of old traditional ways of conducting business and beginning to strategically engage commercial partners in its' exploration plans. It is becoming readily apparent that the next "giant leap" will be a collaborative one that spans government, industry, academia, and international partners.

[1] Epstein, Adam. "How a Bunch of Government Space Geeks at NASA Won the Internet." *Quartz.com.* July 16, 2015.

[2] National Space Policy of the United States of America. 2010.

[3] Pathways to Exploration: Rationales and Approaches for a U.S. Program of Human Space Exploration (2014), National Research Council

[4] OECD (2014), "Reader's Guide", in *The Space Economy at a Glance 2014*, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787.9789264217294-4-en

[5] Remarks by the President on Space Exploration in the 21st Century. April 15, 2010.

[6] United States Public Law 85-567. 1958.

[7] Kelly Dickerson. "Elon Musk: I think we've got a decent shot of sending a person to Mars in 11 or 12 years". *BusinessInsider.com*. April 24, 2015.

[8] 114th Cong. (2014)(testimony of Dr. Sandra Magnus).

[9] New Space Global (NSG) 8 Verticals of New Space, https://app.newspaceglobal.com/images/8verticals.